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ANALYTICAL ABSTRACTS OF CURRENT LITERATURE.[1]

The Age of the Earth, by CLARENCE KING. (American Journal of Science, vol. 45, Jan. 1893, pp. 1–20, with 2 Plates).

The object of Mr. King's paper is to advance the method of determining the earth's age which was employed by Lord Kelvin (Sir William Thomson), and which was based on a consideration of its probable rate of refrigeration, by applying to it new criteria. The criteria are derived from the tidal effective rigidity of the earth, and the further argument for rigidity based upon the periodic variation of latitude, and also from the researches of Dr. Carl Barus upon the latent heat of fusion of the rock diabase, and upon its specific heats when melted and solid, and upon its volume expansion between the solid and melted state. This rock was considered to represent the probable density and composition of the surface .03 or .04 of the earth's radius.

The two principal conditions within the interior of the earth upon which physical state and all purely physical reaction of the specific materials depend, being the distribution from center to surface of pressure and heat, Mr. King points out the relative values of earth-pressures deduced from Laplace's law, and two hypothetical cases of earth-temperatures. These are expressed by a diagram which shows that the temperatures maintain an almost maximum value from within .05 of radius of the surface to the center of the earth, while pressure increases steadily throughout the entire radius. Near the surface the rate of increase of heat is greater than that of pressure, and hence its effect is to overcome the results of pressure. But this relation obtains only for earth-depths of 200 miles for an earth of the Kelvin assumption. Below this the relations are completely reversed.

The results of Barus's researches furnish the means of fixing the melting points of diabase at pressures corresponding to increasing depth within the earth. These points fall in a straight line when plotted on a chart in which the coördinate axes represent temperatures and parts of the earth's radius. By plotting on the same chart curves expressing the temperature gradients of the earth for different assumptions regarding the initial excess of heat and period of cooling, it is possible to determine the extent of the couche which must remain fused in certain cases, and also the temperature gradient at the surface of the earth. From a study of these curves Mr. King is led to conclude that in order to satisfy the conditions of tidal effective rigidity there can be no considerable fused couche within the upper .06 of radius. And since for a given initial temperature the temperature gradient decreases as the period of refrigeration lengthens, an excessive period produces too low a gradient at the surface to satisfy observed rates of heat-augmentation.

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[1] Abstracts in this number are prepared by Joseph P. Iddings, J. A. Bownocker, Henry B. Kummel, Chas. E. Peet.

To meet both these requirements Mr. King selects a gradient which falls below the diabase line of fusion, and emerges at the earth's surface at a rate not less than the mean rate of 64 ft. to 1° F. This corresponds to an initial excess of 1950° C. and a period of 24×10^6 years.

Corrections which should be made to the assumed rate of refrigeration are considered, and found to modify the result but slightly.

In comparing this method of determining the age of the earth with that by Kelvin, based on tidal retardations, King contends that, from abundant geological observation plasticity must be admitted for slow deformations, enormously in excess of the small change of figure which the stress of tidal attraction would produce but for elastic resistance. And although rigidity prevents a sudden tidal deformation of five feet, it does not prevent a slow radial deformation of five miles of the surface matter. Hence it appears that no time measure can be deduced from the supposed fixing of the present ellipticity at some past date.

A very significant comparison of the earth's age is made with that of the sun, which, according to Helmholtz and Kelvin, is 15×10^6 to 20×10^6 years. It is remarked by Newcomb that the period during which the heat received by the earth from the sun has been of a temperature which would permit water to exist in a liquid state upon the earth is probably not more than 10,000,000 years. King calls attention to the fact that all we know of the earlier strata indicates a water mechanism for their deposition, and that the evidences that life was continuous in them necessitates a climate continuously suitable for the circulation of waters. All of this period therefore must have fallen within Newcomb's limits. And the earth's age, about 24,000,000 years, accords with the 15,000,000 or 20,000,000 found for the sun. J. P. I.

The Age of the Earth. By WARREN UPHAM. (American Journal of Science, March, 1893).

Mr. Upham reviews the estimates which have been made concerning the age of the earth. These range from 10,000,000 to 14,000,000,000 years. The most reliable means, the writer argues, for estimating the age of the earth is through comparing the present rate of denudation of continental areas with the greatest determined thickness of the strata referable to the successive time divisions. He assumes the rate adopted by Wallace of a continental reduction of one foot in 3000 years. Taking Houghton's estimate for the thickness of the stratified rocks (177,200 ft.), the time required for their formation, he finds to be 28,000,000 years. Mr. Upham next assumes the thickness of the stratified rocks to be 50 miles, and the rate of land denudation to be one foot in 6000 years. This requires 84,000,000 years for their deposition. Estimates of the relative length of geological time divisions are taken from Dana, Winchell and Davis. Estimating the time since the glacial epoch to be 8000 years, the writer concludes from Davis's ratios, that from 16,000,000 to 40,000,000 years have passed since life first appeared on the globe. From changes in the floras and faunas since the beginning of the tertiary, Mr. Upham thinks the length of Cenozoic time is about 3,000,000 years. Applying this to Dana's and Winchell's ratios, he concludes that about 48,000,000 years have passed since the beginning of Cambrian time. "But," says Mr. Upham, "the diversified types of animal life in the earliest Cambrian faunas surely imply a long antecedent time for their development, on the assumption that the Creator worked before then as during the subsequent ages in the evolution of all living creatures. According to these ratios, therefore, the time needed for the deposition of the earth's stratified rocks and the unfolding of its plant and animal life must be about a hundred million years."

J. A. B.

Continental Problems. ANNUAL ADDRESS BY THE PRESIDENT, G. K. GILBERT. (Bulletin of the Geological Society of America. Vol. 4, pp. 179–190).

Two-fifths of the earth's area has a mean altitude of −14,000 feet, the plateau of the deep sea; one-fourth the continental plateau a mean altitude of +1,000 feet; the remaining third includes the intermediate slopes, the areas of extreme depth and areas of extreme height. With the exception of the Antarctic continent, the continental plateau is a continuous area, whereas the plateau of the deep sea is "separated by tracts of moderate depth into three great bodies, coinciding approximately with the Pacific, Atlantic and Indian oceans." The author discusses briefly several of the unsolved continental problems. (1) By some it is suggested that the continental form is maintained by the solidity and consequent rigidity of the earth; by others the materials underlying the continental plateau are supposed to be lighter than those beneath the oceanic plateau. The difference in density is the complement of the difference in volume. In the author's view the weight of opinion and the weight of evidence is with the latter hypothesis (the doctrine of isostacy). Accepting this doctrine, the question is (2) whether the difference in density is due to difference in temperature or difference in composition. To this question no answer can be given at present. (3) For the origin of the continents the author mentions Dana's hypothesis that the continental areas cooled first and the oceanic last. Only negative results were obtained by the author in examining the configuration of the continental mass in order to see whether it might belt the earth in a great circle. (4) The causes of differential elevation and subsidence within the area of the continental plateau is yet unknown, but in the opinion of American geologists these differential changes of level are conclusive proof that the changes are in the lithosphere and not in the hydrosphere. (5) The doctrine of the permanence of continents is regarded as not yet fully established. (6) The growth of the continents, also, is considered as a question still open to discussion. The author does not think it is fully proved that continental growth has been as steady a process as is generally believed. Most of the evidence appealed to, and the inferences drawn therefrom, concern only the minima of ancient land. The data of unconformities, by which the maxima can alone be determined, are comparatively few, are usually difficult of determination, and therefore have never been fully assembled. Further search ought to be made along these lines before this question can be considered closed.

H. B. K.

Measurement of Geological Time. By T. MELLARD READE, C.E., F.G.S. (The Geological Magazine, March, 1893).

The particles of which the sedimentary rocks are composed have been used again and again in rock building, but were all originally derived from the pre-Cambrian rocks or from igneous rocks of later date. By estimating then the average area of the pre-Cambrian and igneous rocks, the bulk of sedimentary rocks derived from them during Cambrian and post-Cambrian times, and the rate of erosion, calculation may be made of geologic time since the beginning of the Cambrian. The author assumes "for the sake of the calculation," the average area of the pre-Cambrian and igneous rocks to be one-third the whole land area of the globe. The actual bulk of the sediments accumulated since the beginning of the Cambrian is estimated as equal to the present land area two miles thick. The average rate of erosion is taken as one foot in 3000 years. From these estimates the time that has elapsed from the beginning of the Cambrian is in round numbers 95 millions of years. When the enormous length of pre-Cambrian time is added to the above, the estimate is found to agree very closely with that of Sir Archibald Geikie, *i.e.*, 100 to 600 millions years. H. B. K.

Recent Archæological Explorations in the Valley of the Delaware. By CHAS. C. ABBOTT, M.D. (Publications of the University of Pennsylvania).

This work gives the results of the author's recent investigations in the Delaware Valley, principally at two islands near the head of tide water.

Two classes of implements were found ; those of argillite and those of jasper and quartz. He concludes that "an argillite-using man wandered far and wide over this country long before the use of jasper and quartz became so universal." The older "fairly well specialized argillite implements" are, in some localities, found in places at higher levels than the jasper and quartz implements, being deposited when the river flowed at higher levels than at present. However, by erosion and weathering, many of the argillite implements have been dislodged and mingled with the jasper implements along the course of the present river. The subject of palæolithic implements in the undisturbed Trenton gravels is not discussed. The burial customs, earth works, stone mounds, village sites and jasper quarries of the later inhabitants of the valley receive consideration. H. B. K.

The Drainage of the Bernese Jura. By AUGUST F. FOERSTE, with a *Supplementary Note on the Drainage of the Pennsylvania Appalachians.* By W. M. DAVIS. (From Proceedings of the Boston Society of Natural History, Vol. XXV, April 6, 1892, pp. 392–420, 2 plates).

The geological history of the Bernese Jura consists of a series of elevations and depressions, from the Triassic up to the time of the folding in late Tertiary time. The folds have a general east-northeast trend, and were formed by pressure exerted from the southeast along the whole line of the Jura folds. The folds are the strongest along the southeastern border, and decrease in altitude northwestward. They have been considerably eroded. Tertiary and Cretaceous strata are removed from the crests and upper flanks of the higher folds. The drainage lines are : (1) Longitudinal synclinal valleys ; (2) Occasional shallow longitudinal valleys along the crests of the anticlines, and (3) Transverse valleys across the folds. The origin of these transverse valleys, particularly those of the Suxe and the Birse, is the question especially discussed. 1. The absence of faults at the points where the valleys cross the folds is fatal to the theory of their origin through faults, as held by Thurman. 2. Their origin from fractures, as held by Studer, Jaccard, Reutimeyer and Greppin, is improbable, for the fractures are not frequent in the Jura mountains now. That every gap due to fracture should have become a transverse connecting water channel is improbable. Some would have remained as wind gaps. 3. That they did not originate from outlets of lakes, as suggested by Phillipson, and Noe and Margerie, is manifest from the fact (1) That there were lower points by which the lakes could have been drained ; (2) Some of the basins made by the folding have more than one valley cutting through the fold enclosing them. 4. The inconspicuous part played by the lateral streams on the sides of the Jura Mountains is unfavorable to the theory of the origin of the transverse valleys through backward erosion and tapping, as suggested by Heim. Wind gaps representing the backward erosion in various stages ought to exist all over the Jura Mountains, which is contrary to fact. " This theory is particularly at fault when the strange grouping of the cross valleys along *lines* transverse to the folds is observed." 5. Their origin from superimposition is impossible, as the geological conditions required were evidently never present. 6. Mr. Foerste considers them of antecedent origin, and says: "Although the direct evidence of the progressive erosion of the streams during the rising of the folds is lacking, the systematic arrangement of several series of the transverse valleys in straight lines is strongly suggestive of the antecedent origin of the streams. This and the failure of other explanations to meet the facts are the main support of the theory."

Professor Davis notes the bearing of these conclusions on his assumption that the Appalachian streams were consequent. The consequent origin of the Jura streams was cited in support of this assumption. In view of Mr. Foerste's conclusions, Professor Davis withdraws the assumption that the " Appalachian streams were *necessarily* consequent upon the structure of the mountains when they were young," but still thinks that they *probably* were because the deformation of the Appalachians was so much stronger than that of the Jura. C. E. P.

Deep-Sea Sounding. By CAPTAIN A. S. BARKER, U.S.N. (New York: John Wiley & Sons, 133 pp. 3 maps).

This volume gives a brief account of the work done by U. S. S. Enterprise in deep-sea sounding on a cruise from Norfolk, Va., to China and return. The route taken was *via* Cape de Verde Islands, Cape of Good Hope, along the coast of South Africa, thence to Madagascar, the Comoro Islands and Zanzibar, thence across the Indian Ocean to the straits of Sunda, thence to China. Soundings were taken every 100 miles, and sometimes oftener. On the return voyage a line of soundings was made from Wellington, New Zealand to Magellan Straits, and from Montevideo northward off the east coast of South America, at varying distances, as far north as the Bermudas.

On charts accompanying the volume are recorded the depth of the soundings and data concerning the nature of the material of the sea bottom. The deepest sounding was 4,529 fathoms, made to the north of Porto Rico, the position being within forty miles of the deepest sounding (4,561 fathoms) ever taken in the Atlantic Ocean. Two submarine peaks were discovered in the South Atlantic Ocean about 20° west of Cape Town, at a depth of 731 and 979 fathoms. The materials brought up were corals, sand and shells. About 20° east north-east of Montevideo an extensive sand bank was found at a depth of 390 to 500 fathoms. The text is made up of extracts from the ship's log and the captain's private journal. C. E. P.

Observations and Experiments on the Fluctuations in the Level and Rate of Movement of Ground-water on the Wisconsin Agricultural Experiment Station Farm, and at Whitewater, Wisconsin. By FRANKLIN H. KING, Professor of Agricultural Physics, University of Wisconsin. (Washington, D. C.: U. S. Department of Agriculture, Weather Bureau, Bulletin No. 5. 75 pp. Ill., 6 plates).

This bulletin records observations made on the fluctuations of the underground water level from 1888 to July 1892. For the purpose of these observations forty-six wells, varying in depth from five feet to eighty-four feet, within an area 1,200×1,000 feet were available. There are certain short-period changes in level of the ground-water. (1) Those due to seasonal and annual changes in rainfall. (2) Seasonal and mean annual changes in soil temperature develop fluctuations by modifying the rate of percolation and of underground drainage, the changes in temperature influence the viscosity of liquids, and variations in viscosity affect the flow of water through capillary tubes of the soil. Besides these changes the surface of the ground-water level is subject to many slight oscillations, some of them almost beyond measurement. "Oscillations of atmospheric pressure of almost every character affect the under groundwater surface. The longer period barometic changes associated with cyclones, the shorter period changes which accompany thunder storms, and semi-diurnal barometric changes have their corresponding fluctuations in the ground-water." It was found that in recording the rate of flow of a tile drain, a spring and an artesian well, that all three had fluctuations synchronous with the barometric fluctuations. The magnitude of these influences is so great that Prof. King thinks the change in flow from large subterranean drainage areas can be registered upon many rivers and lakes. "The equilibrium of the water, in the capillary soil spaces above the surface of the ground-water, is so unstable that apparently the slightest cause is sufficient to upset it, causing the water to flow out of the non-capillary spaces, but only to be returned again on a moment's notice." The diurnal changes in soil temperature produce corresponding rises and falls of the water surface; "the passage of a train, even where the water is twenty feet below the surface, causes the non-capillary spaces to fill up and empty again as the weight approaches and recedes." No fluctuations due to lunar or solar tidal disturbances were observed. C. E. P.